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MEGARA-GTC stellar spectral library – II. MEGASTAR first release

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ABSTRACT

MEGARA is an optical integral field and multi-object fibre-based spectrograph for the 10.4 m Gran Telescopio CANARIAS that offers medium-to-high spectral resolutions (FWHM) of $R \simeq 6000$, 12 000, 20 000. Commissioned at the telescope in 2017, it started operation as a common-user instrument in 2018. We are creating an instrument-oriented empirical spectral library from MEGARA-GTC stars observations, MEGASTAR, crucial for the correct interpretation of MEGARA data. This piece of work describes the content of the first release of MEGASTAR, formed by the spectra of 414 stars observed with $R \simeq 20\,000$ in the spectral intervals 6420–6790 Å and 8370–8885 Å, and obtained with a continuum average signal-to-noise ratio around 260. We describe the release sample, the observations, the data reduction procedure and the MEGASTAR data base. Additionally, we include in Appendix A an atlas with the complete set of 838 spectra of this first release of the MEGASTAR catalogue.

Key words: astronomical data bases: atlases – astronomical data bases: catalogues – stars: abundance – stars: fundamental parameters.

1 INTRODUCTION

MEGARA, an acronym of Multi Espectrógrafo en GTC de Alta Resolución para Astronomía, is an optical integral field and multi-object spectrograph (MOS) for the Gran Telescopio CANARIAS (GTC). The MEGARA project was carried out by a consortium formed by the Universidad Complutense de Madrid (Spain) as the leading institution, the Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico), the Instituto de Astrofísica de Andalucía (Spain), and the Universidad Politécnica de Madrid (Spain), with the participation of European, Mexican, and US companies. In particular, the Spanish company FRACTAL SLNE played a key role by taking responsibility for the project management and system engineering, among other work packages. MEGARA accomplished its mission successfully: it finished fulfilling all the requirements within budget and schedule. The instrument combines versatility and performance offering both bidimensional and MOS high-efficiency spectroscopy with three spectral resolutions. MEGARA commissioning at GTC concluded on 2017 August 31 and was offered to the community in the second observing semester of 2018.

For a detailed description of the instrument and its scientific validation, see Carrasco et al. (2018), Gil de Paz et al. (2018, 2020), and Dullo et al. (2019). Here, we present a summary for completeness. Its main characteristics are shown in Table 1. In the bidimensional mode, an integral field unit (IFU) called a large compact bundle (LCB) provides a field of view (FoV) of 12.5 × 11.3 arcsec, plus eight additional seven-fibre minibundles for sky subtraction, located in the external part of the MOS field. In the MOS mode, 92 robotic positioners, each with a seven-fibre minibundle, cover an area on sky of 3.5 × 3.5 arcmin. The spatial sampling in both modes is 0.62 arcsec per fibre. Each spaxel size is a combination of a 100 µm core fibre coupled to a microlens that converts the f/17 entrance telescope beam to f/3 to minimize focal ratio degradation.

MEGARA provides low resolution, LR, $R(\mathrm{FWHM}) = 6000$; medium resolution, MR, $R(\mathrm{FWHM}) = 12\,000$; and high resolution, HR, $R(\mathrm{FWHM}) = 20\,000$. In LR and MR with 6 and 10 volume phase holographic (VPH) gratings, respectively, the wavelength interval coverage is 3650–9750 Å. In HR, using two gratings, the wavelength range is 6405–6797 Å for HR-*R* and 8360–8890 Å for HR-*I*.

The MEGASTAR library is an ambitious long-term project with the goal of having stellar spectra in as many as spectral configurations as shown in Table 1, although the priority is now to complete a large enough library in the HR set-ups. This is the second of a series of papers relating to the MEGARA-GTC library. In the first one (García-Vargas et al. 2020, hereafter Paper I), the authors comprehensively described this MEGARA-GTC spectral library and the rationale behind the 2988 star catalogue. It was created from libraries whose spectral resolutions are similar to that of MEGARA at LR, MR, and HR, covering a wide interval in T_{eff}, $\log g$, and abundance [M/H], generally as [Fe/H], and that could be observed from

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Table 1. Main characteristics of MEGARA at GTC.

IFU (LCB) FoV		12.5×11.3 arcsec
LCB multiplexing		623 + 56 sky fibres
MOS FoV		3.5×3.5 arcmin
MOS multiplexing		644
Spaxel (LCB/MOS)		0.62 arcsec
Resolving power	LR	6000
	MR	12 000
	HR	20 000
Spectral configurations	6 LR, 10 MR, and 2 HR	
Wavelength intervals	LR	3650–9750 Å
	MR	3650–9750 Å
	HR	6420–6790 Å
		8370–8885 Å

the Observatorio del Roque de los Muchachos with geographical coordinates 28°45′25″N latitude, 17°53′33″W longitude.

A discussion of the fundamental role of spectral libraries in single stellar population (SSP) models and the advantages and constraints introduced by theoretical and empirical libraries in these models is presented in Paper I. The main motivation of the MEGASTAR library is to produce a spectral atlas to be used as input spectra for POPSTAR models (see e.g. Mollá, García-Vargas & Bressan 2009; Martín-Manjón et al. 2010; García-Vargas, Mollá & Martín-Manjón 2013) to create the synthetic templates required to interpret the observations taken with the same instrument set-up. To delimit the goal we have concentrated on HR-*R* and HR-*I* spectral configurations with $R \simeq 20\,000$, centred in the rest frame at H α and the brightest line of the Ca II triplet, respectively, as there are no published theoretical or empirical catalogues with these resolution and spectral intervals. Moreover, such resolution with the combination of efficiency and telescope collecting area has not been provided by any other integral field instrument.

In this paper we present the first release of the MEGASTAR library formed by 838 spectra obtained in the two high-resolution spectral configurations: HR-*R* and HR-*I*. This is the result of 152.25 h of *filler*-type observing time of 414 stars, covering different spectral types, effective temperature, surface gravity and abundances. The complete atlas with fully reduced and calibrated spectra will be available to the community at the time of the acceptance of this publication (https://www.fractal-es.com/megaragtc-stellarlibrary). In Section 2, we describe the main characteristics of the stars in this release. The observations and the data reduction pipeline are summarized in Sections 3 and 4, respectively. The data base produced to manage the star catalogue, the observation proposal preparation, the resulting observations, and the release itself are presented in Section 5. Some examples of our spectra are given in Section 6 and in Section 7 a summary and final remarks are included. We present in Appendix A an atlas with 838 spectra, corresponding to the 414 stars of this first release. Appendix B is the release summary table and Appendix C contains a table with *Gaia* DR2 data for the 388 stars of the release for which *Gaia* data exist. These three appendices will be published in the online version only.

2 SAMPLE

The distribution of the stellar types, retrieved from the SIMBAD astronomical data base, CDS[1], or from published papers in the literature is shown in the left-hand panel of Fig. 1. The red dashed-line region represents the parameters for the whole MEGASTAR library while the solid blue bars indicate the present data release (1.0), DR-1 stars. The dominant spectral types in this release are G (113) and B (107), followed by F (77), K (39), A (29), O (27), M (13), W (7), S (1), and Flat (1). In the right-hand panel we present the $\log g$ versus $\Theta = 5040/T_{\rm eff}$ diagram, over which we have plotted as cyan dots the values of the stars of the whole MEGARA library with estimated stellar parameters from the literature and those from DR-1 plotted as blue circles, green squares, and red triangles according to the three metallicity ranges as indicated in the plot. Finally, we have overprinted the Padova isochrones (Bertelli et al. 1994; Girardi et al. 2000; Marigo et al. 2008) since these are the ones used in the evolutionary synthesis POPSTAR models (see Mollá et al. 2009), which will be used in combination with MEGASTAR to provide a MEGARA-oriented set of spectra. The continuous update of this plot allows us to identify which areas of the physical parameter space must be completed to prioritize the future observations of the corresponding library stars, within the limitations of the *filler*-type program.

These stars cover the values of $T_{\rm eff}$, $\log g$, and abundance [M/H] presented in Fig. 2, where Ntot indicates the number of points used for each histogram, since for some stars one or more stellar parameters were not reported in the literature when we created the MEGASTAR catalogue. One of the goals of our project is to develop a method to homogeneously derive the stellar parameters for all the stars in the library. In particular, in Paper I we proposed a technique to estimate these parameters by using the best-fitting theoretical models to the combined spectrum of HR-*R* and HR-*I* of 97 stars. We plan to apply this method to the 414 stars of this release in a forthcoming paper.

To juxtapose our sample with *Gaia*[2] data, we found DR2 measurements for 388 MEGARA library stars. In the top panel of Fig. 3 we present a Hertzsprung–Russell diagram (HRD) showing the density of 65 921 112 *Gaia* stars in DR2 with good-quality parallax and photometry measurements, i.e. $\Delta\varpi/\varpi < 0.1$, $\sigma_G < 0.022$ mag, and $\sigma_{G_{XP}} < 0.054$ mag (see fig. 1 in Babusiaux et al. 2018, from the Gaia Collaboration). A Gaussian kernel-density estimate has been applied to the stellar density map. The units in this map are normalized to the maximum star density and the colour map is shown in a logarithmic scale; a lower threshold of 10^{-6} for the stellar density has been set. In the bottom panel of the same figure we show the HRD of *Gaia* DR2 stars with identical maximum parallax and photometry uncertainties as panel (a) but selecting only those 1322 033 solar neighbourhood stars with parallaxes $\varpi > 5$ mas, that is, heliocentric distances below 200 pc. The MEGARA library stars with *Gaia* DR2 measurements are shown as light-blue filled circles. There is a lack of late-type stars due to the low fraction of main-sequence K and M stars in this release sample, around 13 per cent, particularly those with reliable *Gaia* DR2 measurements. Note that the *Gaia* DR2 saturation limit is at $G = 3$ but at $G < 6$ the quality of the astrometry starts to worsen (Lindegren et al. 2018). In Appendix B we include an extract of the *Gaia* DR2 measurements for 388 out of the 414 stars of MEGARA release 1.0. The details are described in Section 6.3.

3 OBSERVATIONS

Observations of the library are in progress and GTC open time has been awarded in four consecutive semesters. The observations included in this release 1.0 of MEGASTAR are from programmes

[1] http://simbad.u-strasbg.fr/

[2] https://gea.esac.esa.int/archive/documentation/GDR/

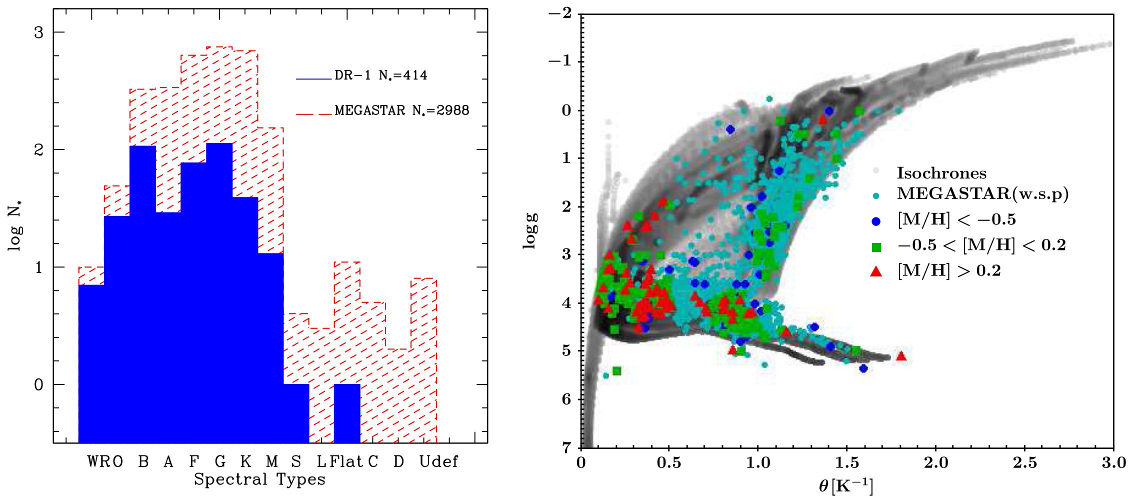

Figure 1. Properties of the release stars compared with the whole MEGASTAR library. Left: Distribution of spectral types retrieved from SIMBAD. The complete library MEGASTAR is shown in red, that corresponding to this data release (1.0) DR-1 in blue. The y-axis is in logarithmic scale. Right: Surface gravity log g versus $\Theta = 5040/T_{\rm eff}$ diagram. We show (1) the values given by the Padova isochrones, which we would need for a synthesis code such as POPSTAR, in grey-scale (more intense in regions where there are more points); (2) the stars from the MEGASTAR library, with stellar parameters (w.s.p.) available in the literature, as cyan dots, and (3) the stars of this release shown with three metallicity intervals, indicated by different colours as labelled.

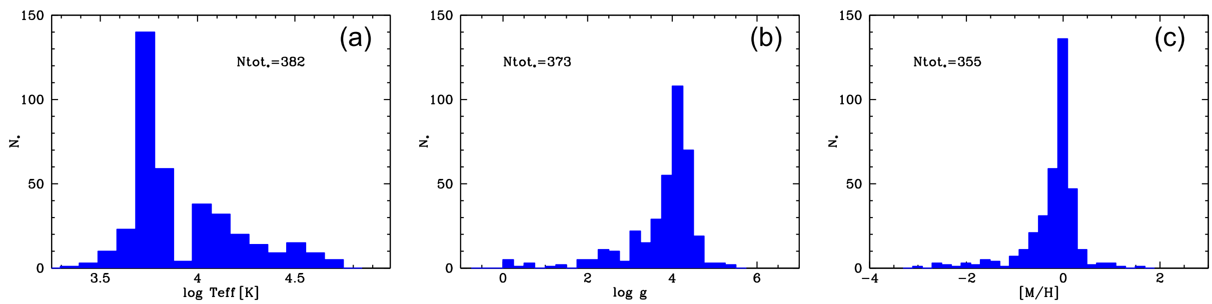

Figure 2. Histogram of the number of stars in this release as a function of $T_{\rm eff}$ (a), log g (b), and [M/H] (c). Ntot indicates the number of points in each graph.

GTC22/18B, GTC37/19A, and GTC33/19B, with a total of 152.24 h of observed *filler*-type GTC open time. Table 2 shows the time requested, awarded, and observed through the three semesters whose observations are included in this release. 414 stars were observed were but five of them were observed twice; therefore we are reporting 419 observations carried out in the HR-R and HR-I spectral configurations, producing a total of 838 spectra. Additionally, the project was awarded another 75 h in 2020A.

The MEGASTAR library observations have been carried out as a *filler*-type program that, according to GTC rules, must accept the following values: seeing generally larger than 1.5 arcsec, any night type, especially bright and any kind of sky quality, in particular spectroscopic (non-photometric) time, with the possibility of having bad seeing being the most important criterion. The seeing distribution, as reported in GTC log files, is shown in Fig. 4 with first-quartile, median, and third-quartile values of 1, 1.8, and 2 arcsec, respectively. Nevertheless, the great advantage of creating a stellar library with an IFU instrument is that the spectral resolution is conserved as the slit width is constant as long as the stop is at the microlens + fibre. In fact, to ensure that the flux was recovered in all the cases, we always added the individual spectra from 37 spaxels centred in the highest-flux fibre in the reconstructed LCB images. Most stars were observed in bright conditions. The telescope delivers a standard star per observing block (OB) for flux calibration and instrument response correction.

Thanks to the optimization of the observational strategy, the priority given to bright stars, and, overall, the manoeuvring and GTC overhead time saving to observe HR-R and HR-I in the same OB, in the three already fully observed semesters, the charged time per OB ranges from 850–1600 s for V-magnitude stars brighter than 12.5 with an average value of 1100 s star^{-1} with the two set-ups, so that we have increased the originally expected efficiency by a factor of 1.6.

The limiting V magnitude of the observed stars is 12.4. So far we have observed 80 stars with $T_{\rm eff}$ > 20 000 K, seven of them being WR stars. This will allow us to produce an initial version of our R = 20 000 SSP models for young populations. The targets proposed for the complete library are available through the MEGARA-GTC-library data base described in Section 5. The data base supports the working team for preparing and uploading the OBs to the GTC Phase 2 tool. To prepare a new OB set, we search unobserved stars in the MEGARA-GTC library filtered by a certain magnitude range in both the R and I bands and/or by spectral type or any stellar parameter, considering that all stars within that group and for a given set-up will have a similar signal-to-noise (S/N) ratio when choosing the appropriate exposure time in each set-up. The exposure times were

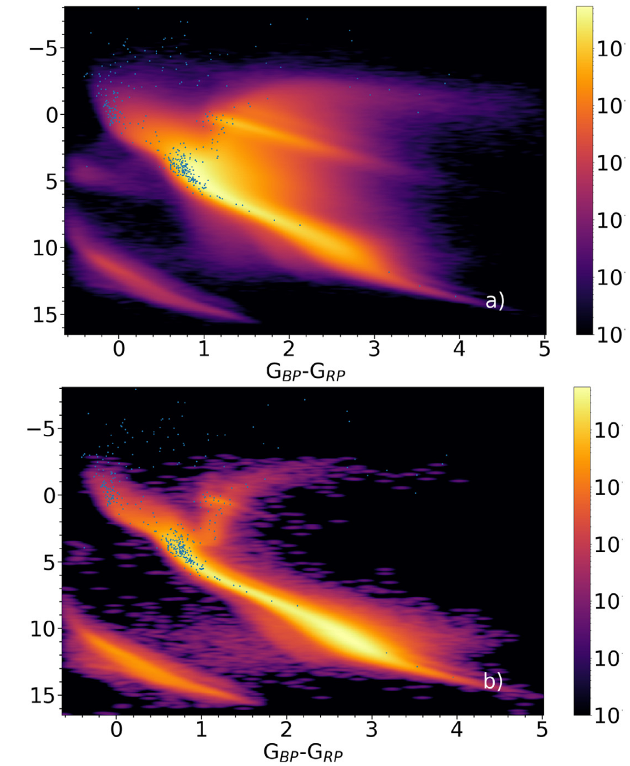

Figure 3. a) HRD showing the density of 65 921 112 *Gaia* stars in DR2; b) HRD of *Gaia* DR2 stars with identical maximum parallax and photometry uncertainties as in panel (a) but selecting only those 1322 033 solar neighbourhood stars. The 388 MEGARA-GTC spectral library with *Gaia* DR2 measurements are shown as light-blue filled circles.

Table 2. MEGARA-GTC spectral library observing time.

Semester	Requested h	Granted h	Observed h	Stars observed
2018B	50	50	63.85	176
2019A	50	50	11.66	32
2019B	75	75	76.73	206
Total	175	175	152.24	414

estimated using the MEGARA exposure time calculator (ETC) tool[3] to obtain S/N ratio values between 20 and 300. When the exposure time resulting from the ETC was longer than 30 s, we preferred to divide it into three exposures to be able to calculate the median of the three images to eliminate cosmic rays. Calibration images of halogen and ThNe lamps were obtained during the daytime.

4 DATA REDUCTION

The data reduction procedure was carried out using the MEGARA data reduction pipeline (DRP),[4] publicly available and open source under GPLv3+ (GNU Public License, version 3 or later). It is a custom-made user-friendly tool formed by a set of processing recipes developed in PYTHON (Cardiel & Pascual 2018; Pascual et al. 2018, 2019). The recipes used for obtaining all the calibration

[3]http://gtc-phase2.gtc.iac.es/mect/etc/form
[4] https://github.com/guaix-ucm/megaradrp

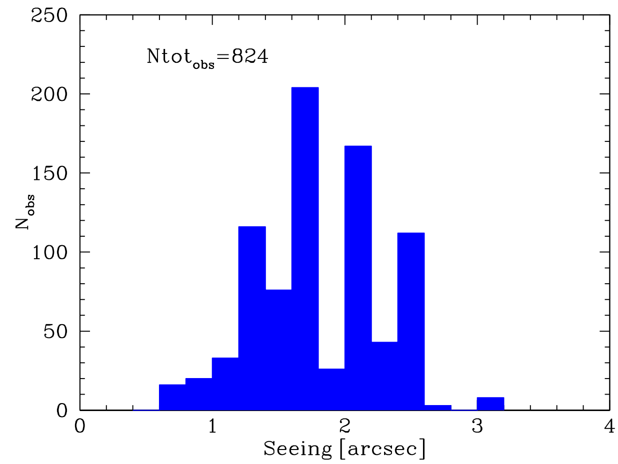

Figure 4. Histogram of the seeing conditions during the observations of the MEGASTAR first release. $Ntot_{obs}$ is the number of observations with a seeing measurement reported. The values of the first quartile, the median, and the third quartile of the seeing distribution are 1.5, 1.8, and 2.0 arcsec respectively.

images were *MegaraBiasImage*, *MegaraTraceMap*, *MegaraModelMap*, *MegaraArcCalibration*, *MegaraFiberFlatImage*, and *MegaraLcbStdStar*. Each recipe generates a product: a master bias image for bias subtraction; a trace map for fibre tracing; a model map for spectra extraction, as a result of a simultaneous fit to all the fibre profiles; a wavelength map for wavelength calibration; a fibre flat-field map for pixel-to-pixel relative sensitivity; and a master sensitivity function for flux calibration and instrument response correction. Each product has to be copied to a specific directory, previously defined by a calibration file tree structure (see Castillo-Morales, Pascual & Gil de Paz 2018). Additionally, each routine generates a quality-control file allowing full tracking of the process. Halogen and ThNe lamp exposures are required for tracing flat-field and wavelength calibration. MEGARA DRP uses a general configuration file with the information necessary for data reduction like data directories, the polynomial degree, and the number of spectral lines required for wavelength calibration and the observatory extinction curve, among others. It operates in a sequential mode, i.e. each recipe requires products generated in the previous ones. An individual routine has its own input .YAML file that includes the images to be processed and the specific parameters required for that particular recipe. For example, when the temperature of the halogen lamp observations differs more than one degree from that of the source, a global offset must be applied for fibre tracing, which is done by giving a value to the *extraction_offset* parameter.

The last step is to apply the recipe *MegaraLcbImage* to the star image. This produces a row-stacked-spectra file with the individual fibre spectra corrected for atmospheric extinction and instrument response and flux calibrated. The sky subtraction is carried out automatically by calculating the median of the signal of the eight sky minibundles located outside the LCB FoV. The top panel of Fig. 5 shows the reconstructed image of the star HD 048682, generated by the quick look analysis (QLA) tool (Gómez-Alvarez et al. 2018). The rectangular shape is the reconstruction of the LCB such that the dimensions are equivalent to 12.5 × 11.3 arcsec and the eight sky-minibundle projections are shown in the external part of the LCB. The view of these sky minibundles has been collapsed for visualization purposes but they are located between 1.75 and 2.5 arcmin from the centre of the IFU. To extract the 1D spectrum we integrated three rings formed by 37 spaxels, shown in red, each

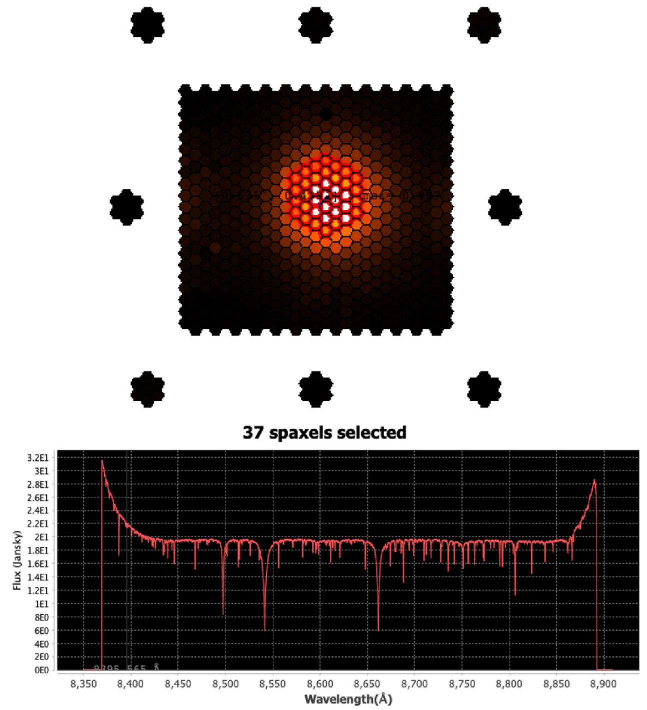

Figure 5. Layout of the QLA tool. Top: reconstructed image of the star HD 048682 on the LCB; the eight minibundles in the external part, collapsed for visualization, are used for sky subtraction. Bottom: final HR-*I* spectrum corresponding to the 37 selected spaxels marked in red in the LCB. The seeing during this observation was reported to be 2.5 arcsec.

equivalent to 0.62 arcsec on the sky. In the bottom panel the final HR-*I* spectrum corresponding to these 37 spaxels, after flux calibration and instrument response correction, is displayed. All the spectra were extracted in the same wavelength range: 6420–6790 Å in HR-*R* and 8370–8885 Å in HR-*I*. The flux is given in Jy.

We note that at the extreme wavelengths of the spectrum, shown in Fig. 5, the flux tends to rise. This effect, present in most of the spectra, is due to the coarse reciprocal dispersion and spectral resolution of the tabulated spectra of most spectrophotometric standard stars. During the determination of the system sensitivity function we had to degrade the MEGARA HR-*R* and HR-*I* observations of our standard stars. This coarse resolution implies that the tabulated fluxes at the edges of the wavelength range covered by these VPHs are affected by fluxes that correspond to wavelengths that are not explored by our data. Therefore, we ought to degrade the MEGARA observations of these standards using (null) fluxes that would come from wavelengths beyond each specific observed interval. This leads the degraded reference spectrum and the corresponding master sensitivity curve to drop faster at these extreme wavelengths, ∼50 Å at each size, than the actual system sensitivity. As a consequence of this edge effect, the flux-calibrated spectra tend to rise at the very extremes of each specific wavelength range.

In order to obtain a first-order correction to this effect we have divided every spectrum by a normalized continuum obtained from the fitting to the rather flat HR-*R* and HR-*I* spectra of BD+083095. The corresponding fits were performed following the same approach described in Paper I. Fig. 9 shows the result for BD+083095. All the stars of the release have been corrected with this normalized continuum. It is important to remark that this is not producing spectra normalized to the continuum. In Paper III a specific continuum fitting for each star will be carry out as part of the procedure for determining the physical stellar parameters. Accordingly, in the next release we will also include all normalized spectra.

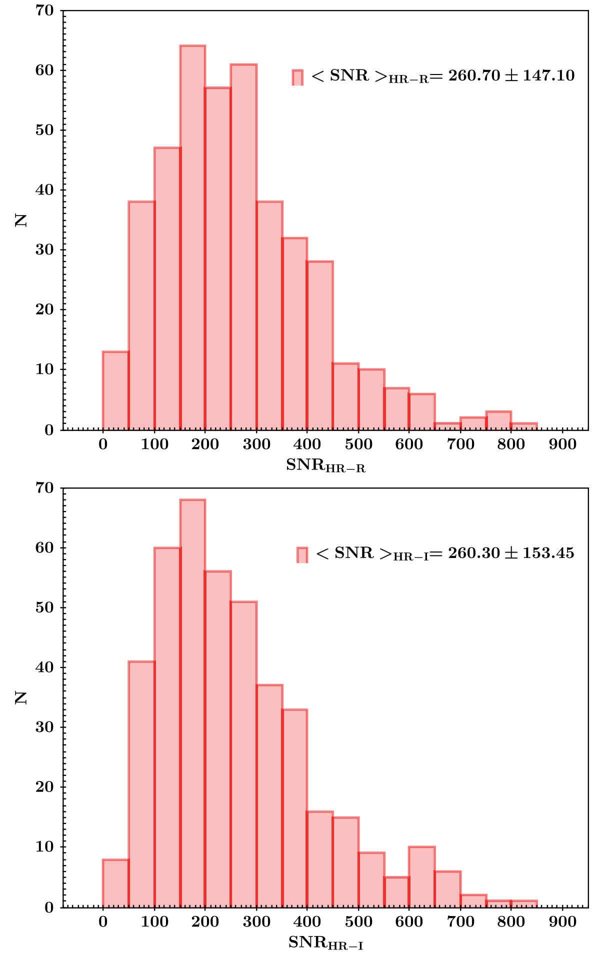

Figure 6. Distribution of the S/N ratio obtained according to Stoehr et al. (2008) for the HR-*R* (top) and HR-*I* (bottom) spectra of MEGASTAR release 1.0.

To assess the quality of the spectra, we report in Fig. 6 the distribution of the measured continuum S/N ratio averaged over the whole spectrum, following the recipe by Stoehr et al. (2008), for the HR-*R* and HR-*I* spectral configurations in the top and bottom panels, respectively. In both cases the average S/N ratio is around 260. The plots are similar since most of the star observations included the two spectroscopy set-ups in the same OB to be executed in sequence. The S/N ratio distribution spreading over a wide range of values is a consequence of the nature of the GTC *filler*-type program itself that does not guarantee any specific observing conditions. On the contrary, these observations are conducted randomly and out of the standard scheduling, normally done whenever other programmed observations cannot be executed. This is due mostly to bad observing conditions but filler observations can be carried out just to complete the night time or during twilight, and sometimes the conditions can be good.

Additionally, any single observation has to be executed with the exposure time pre-defined in the GTC Phase 2 tool. In other standard programs the observing conditions are guaranteed and the exposure time is estimated accordingly. In MEGASTAR observations, the integration time has to be pre-defined no matter what the observing conditions are, increasing the uncertainty to the observation quality.

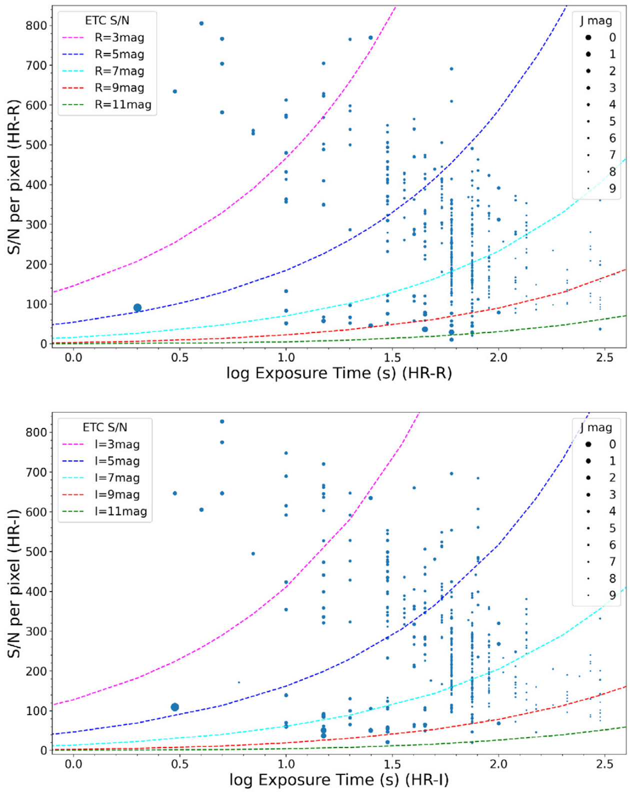

Figure 7. S/N ratio as a function of the total exposure time. The size of each circle is proportional to the apparent brightness of the star in the J band for the HR-R (top) and the HR-I (bottom) spectra. As a reference, we include the S/N ratio predictions of the MEGARA ETC for different R-band and I-band magnitudes as indicated, considering average observing conditions. For more details see Section 4.

Our decision of extracting 37 spaxels for all spectra, regardless of the seeing value, guarantees that all the flux is integrated, and generally improves the S/N ratio for bad seeing observations but might degrade it for very good seeing conditions since in these cases we are mostly adding noise when extracting all 37 spaxels.

Fig. 7 shows the S/N ratio as a function of the total exposure time for the HR-R and HR-I spectra in the top and bottom panels, respectively. The size of each filled circle is proportional to the apparent brightness of the star in the J band as this magnitude is the one available for the vast majority (all but four) of our stars while only 290 (284) stars have published R-band (I-band) magnitudes. We also include in this plot, as a reference, the predictions of the MEGARA ETC for the S/N ratio per spectral pixel at the central wavelength of the VPH for different R-band magnitudes in the case of HR-R and I-band magnitudes for HR-I, assuming spectroscopic conditions, full moon, airmass of 1.15, 1.5 arcsec seeing, and a flat input spectrum, after adding up only 19 spaxels centred on the source, considering that in these ETC simulations the seeing is relatively good. Note that all magnitudes used here are in the Vega system.

5 MEGARA-GTC LIBRARY DATA BASE

Our goal in this project has been twofold, to assemble input spectra for POPSTAR models for the interpretation of stellar populations in a broad range of observations with MEGARA, and to generate a public data base of reduced and calibrated spectra for other MEGARA users. We developed a data base in MYSQL and a web-based tool to manage the stellar data and the observed spectra that will be available to the community as part of this MEGASTAR release 1.0. Via a scheme of permission levels, different actions are allowed. The public user will be able to retrieve the information compiled for each star and observations and to download the individual reduced spectrum or the full release as described in this section.

The data base resides on https://www.fractal-es.com/megaragtc-stellarlibrary/ and offers different menus: source, observations, library completion, download, utilities, project description, and papers. The left-hand panel of Fig. 8 shows the menus available. The source functionality allows the user to list the sources of the complete library; to search sources when filtering by different parameters such as source name, RA, Dec., and spectral type, among others, and to browse observations of a source. The filtering parameters are those created in the source form where the complete star information resides. In the top right-hand panel of Fig. 8 the layout of the source form is shown for the star BD+083095: its RA and Dec. coordinates, the corresponding ΔRA and ΔDec. proper motions, the spectral type and luminosity class, and the U, B, V, R, I & J Johnson–Cousins magnitudes retrieved from the SIMBAD data base are displayed. This star was observed in the GTC observing semester 2018B. In this example, the stellar parameters $T_{\rm eff}$, log g, and [Fe/H] were extracted from the HARPS catalogue. In the $T_{\rm eff}$–L, log g–L, and [Fe/H]–L windows the 'L' stands for our own library determination of the stellar physical parameters that will be provided in the near future. The comments section shows that the star was observed in both HR-R and HR-I set-ups. In other comments is the reference to the HARPS project publication from which the star and the values of the physical parameters $T_{\rm eff}$, log g, and [Fe/H] were compiled.

The observations menu allows listing and searching of observations, filtering them by source name, RA, Dec., VPH, and instrument mode, among other parameters, as seen in the bottom left-hand panel of Fig. 8. An observation form is created for each spectral set-up observation, as shown in the bottom right-hand panel of the same figure for an HR-I observation. The first window has the name and coordinates of the star retrieved from the source form. In the observation data window the following information is provided: BD+083095_27487_HR-I id is a unique code used internally to identify the observation; the star was observed in the HR-I set-up with three exposures of 60 s each, under 1.5 arcsec seeing, while the temperature at the MEGARA spectrograph bench was 15.7 °C; the HR-I spectrum is public. In the comments window GTC22-18B_0154 indicates that MEGARA library observing program has assigned the code GTC22, the OB number is 0154, and the observation was carried out on 2019 February 22. The data products available are the HR-I spectra in two formats, with BD+083095_27487_HR-I_waveJ.fits and BD+083095_27487_HR-I_waveJ.ascii being their filenames; the 'J' in the filenames indicates that the flux-calibrated spectra are provided in Jy. The calibration comments window shows the DRP recipes used in the data reduction process described in Section 4: in summary, that the spectrum was obtained after bias subtraction, fibre tracing, wavelength calibration, flat-field, extraction, extinction, and spectral response correction and flux calibration. The individual spectrum can be visualized by clicking the HR-I or HR-R buttons in the observation list menu. In this case, the spectra that would be displayed for the star BD+083095 are shown in Fig. 9. All the lists created in the source and observations menus can be exported to PDF, MSEXCEL, or ASCII files.

In the library completion menu the full library button paints a graph of all the stars of the library grouped by three ranges of metallicity: $[{\rm Fe/H}] < -0.7$, $-0.7 \le [{\rm Fe/H}] \le -0.2$, and $[{\rm Fe/H}] > -0.2$, while the observed stars button paints a plot with all the stars observed

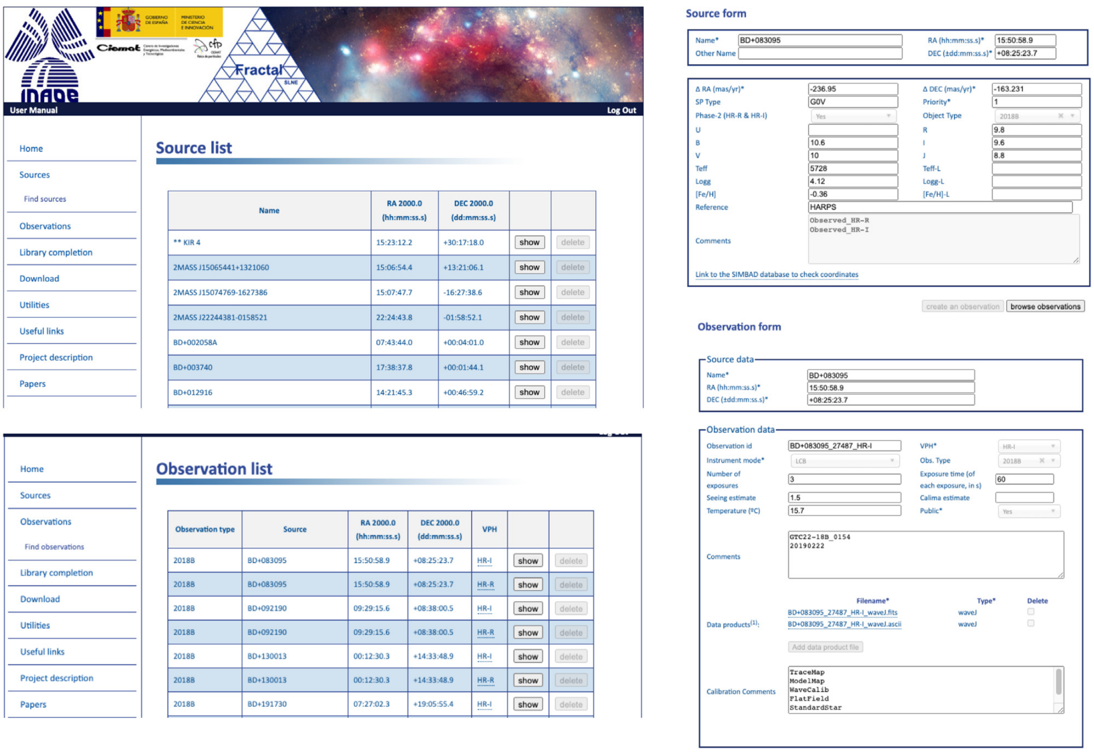

Figure 8. MEGARA-GTC library data base user interface. Left: source list and observation list options. Right: source form for BD+083095 with the complete information on the star and observation form with the details of HR-*I* observation of the same star.

in the same defined [Fe/H] intervals. Furthermore, in case the user wishes to upload her/his own stars, she/he can choose to overlay the graph with one of these two graphics: full library or observed stars. In the utilities menu the user can download the spectra plot application to plot the data product files. The useful links menu includes links to ING Object Visibility–STARALT, to the SIMBAD astronomical data base, and to the MEGARA exposure time calculator.

The download menu leads to the link ‘click here to download the lastest release’. The current release 1.0 presented in this paper contains observed and calibrated spectra from the MEGASTAR library stars after a basic quality-control check. All spectra were reduced with MEGARA DRP passing through all standard reduction steps described in Section 4. The release download includes: (i) a readme.txt file with the description and the content of the release; (ii) a list of the stars with a description of the observations (release_summary_1.0) in MSEXCEL and ASCII formats; (iii) a main directory and three sub-directories with the release spectra in ASCII, FITS, and JPG formats; and (iv) a JAVA application for the display of the observations.

The star information in the release files is mainly that displayed in the sources and observations forms. The column headers of the release_summary_1.0 (.xls and .txt) files, shown in Table 3, are as follows: name, main star name; right ascension (RA) and declination (Dec.) in equatorial coordinates J2000.0, spectral type and luminosity class; and referenced available Johnson–Cousins magnitudes *U, B, V, R, I*, and *J*; all these parameters are obtained from the SIMBAD data base, updated to 2020 July 8. The other name column is for any alternative names for the star. The next one shows the VPH grating used in the observation; the values for effective temperature, surface gravity (log), and iron abundance (log) T_{eff}, log g, and [Fe/H] are displayed in the next three columns, respectively, for those stars whose values have been extracted from other libraries. In the reference column is the name of the original catalogue from which the star was selected; other comments are those relating to the star. The next two columns indicate the name of the ASCII/FITS spectrum file provided by the release and the GTC observing semester, obs. period. The observation parameters of each star are presented in the next three columns: the number of exposures, No. exp., and the exposure time, exp. time (s), from the images headers and the seeing (arcsec) as reported by GTC in the observation log file. The last one, obs-GTC, displays comments relating to the observations including the OB number and the observation date. The release_summary_1.0 files (.xls and .txt) are included in Appendix B.

The main directory observations_release_1.0 has the ASCII, FITS, and JPG sub-directories with the release spectra in the corresponding formats and three files with the spectra lists. An example of the JPG spectra is shown in Fig. 9 for the star BD+083095 in HR-*R* and HR-*I*; the header of the plot includes the spectrum filename. The JAVA application spectraplot.jar allows further visualization and basic analysis of the ASCII or FITS spectra. The JAVA plots includes the star name, the spectrograph set-up, the spectral type, and the values of T_{eff}, log g, and [Fe/H] from the literature whenever available.

6 MEGASTAR LIBRARY FIRST-RELEASE STARS

6.1 MEGARA stellar atlas

In Appendix A, available online, we present an atlas of the 838 spectra of this first MEGASTAR release, ordered alphabetically by star name. In Table 5 we list the names of the stars in the same way as their spectra are displayed in the corresponding page of that appendix. To illustrate the content of the atlas, Fig. 10 shows an extract of 28 spectra of 14 stars. For each star the atlas displays the HR-*R*,

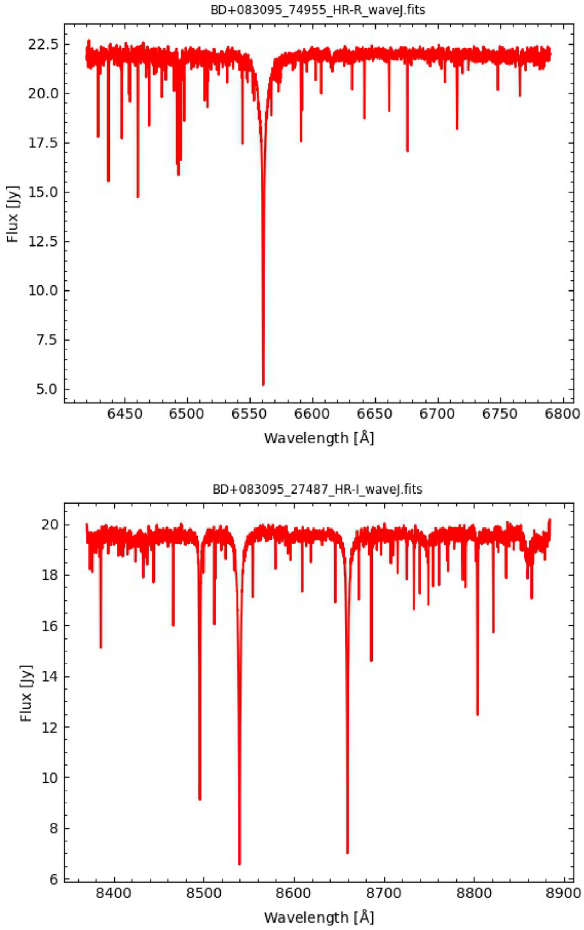

Figure 9. Example of the final spectra in JPG of the star BD+083095 obtained in the HR-*R* (top) and HR-*I* (bottom) set-ups. All the spectra of the release are provided in JPG, FITS, and ASCII.

from 6400–6800 Å, on the left, followed by the HR-*I*, from 8450–8850 Å, on the right. The star name, the spectral type, and the stellar parameters compiled from the literature (if they exist) are labelled inside each HR-*I* plot. The colour of the spectrum has been associated with the star spectral type in the literature as follows: purple, WR; blue, O; cyan, B; green, A; orange, F; red, G; magenta, K; maroon, M; grey, S; and black, flat. Spectra shown in Fig. 10 are therefore from stars of different spectral type and luminosity class, in particular, from left to right and from top to bottom, F3 (BD−0322525), sdF8 (BD+191730), G0 (G234−28), A1V (HD 014191), O5e (HD 015558), WC6 (HD 016523), B9IV (HD 027295), O9.5Ia (HD 030614), M1.5Ia (HD 035601), B9V (HD 037269), A2II (HD 039866), K0 (HD 042983), S4.5 (HD 064332) and G8V (HD 101501).

Fig. 11 shows a spectral-type sequence of HR-*R* and HR-*I* observations of stars of this release, highlighting the diversity of spectral types of the MEGASTAR release. For this figure the spectra were normalized dividing by the flux at λ = 6650 Å in HR-*R* and at λ = 8780 Å in HR-*I*, and shifted vertically. On the left-hand side of the figure the HR-*R* set-up spectra are shown, while on the right-hand side the corresponding HR-*I* set-up spectra are presented. Each stellar spectrum has the name of the star in the HR-*R* panel and the corresponding spectral type in the HR-*I* panel.

Table 3. Column description of the release_summary_1.0 file, included in Appendix B, available online only.

Column	Description
Name	Star name (∗)
RA	Right ascension (2000.0) (hh:mm:ss.s) (∗)
Dec.	Declination (2000.0) (dd:dd:ss.s) (∗)
Sp. type	Spectral type (∗)
U	Johnson–Cousins *U* magnitude (∗)
B	Johnson–Cousins *B* magnitude (∗)
V	Johnson–Cousins *V* magnitude (∗)
R	Johnson–Cousins *R* magnitude (∗)
I	Johnson–Cousins *I* magnitude (∗)
J	Johnson–Cousins *J* magnitude (∗)
Other name	Alternative name for the star
VPH	Grating of the observed spectrum
T_{eff}	Effective temperature from the literature
log *g*	Surface gravity (log) from the literature
[Fe/H]	Iron abundance (log) from the literature
Reference	Original catalogue from which it was inherited
Other comments	Comments relating to the star
ASCII/FITS file	Name of the ASCII/FITS spectrum file
Obs. period	GTC observing semester
No. exp.	Number of exposures
Exp. time	Time of the individual exposures (s)
Seeing	Value of the seeing as reported by GTC (arcsec)
Obs-GTC	Comments relating to the observations

Note.(∗) Source: SIMBAD.

6.2 Examples of hot stars

The first release of the MEGARA-GTC library also includes a representative sample of hot stars, i.e. there are 51 OB stars earlier than B3 and seven Wolf–Rayet stars. As an example, in Fig. 12 we show the spectra obtained for three of them: HD 006327 (or WR#2), HD 000108, and HD 058343.

HD 006327 is one of the hottest stars in the Milky Way, located in the Cas OB1 association. Moreover, it is the only known WN2 star in our Galaxy with an estimated temperature of ∼140 kK (see Hamann, Gräfener & Liermann 2006; Hamann et al. 2019). HD 006327 is a firm gamma-ray burst candidate (Sander, Hamann & Todt 2012) that has singular characteristics, such as unusually rounded emission line profiles (Haman et al. 2006; Chené et al. 2019) that are not present in other early-type WN stars (see e.g. Hiltner & Schild 1966; Conti, Massey & Vreux 1990). This feature can be clearly seen in our HR-*R* spectrum. Although it has been proposed to be a fast rotator or even a visual binary (Crowther 1993), in a recent deep spectroscopic study by Chené et al. (2019), they found no evidence for any of these scenarios.

HD 000108 is an Of?p star (Walborn et al. 2010) that shows spectroscopic variations caused by magnetic effects (Nazé, Walborn & Martins 2008). Recently, Maíz Apellániz et al. (2019) identified its two extreme states and provided a combined classification of O6.5–8.5 f?p var. It is an example of extreme rotational braking, with a rotational period of between 50 and 60 yr (Nazé et al. 2010). A comparison of the H α line profiles in our HR-*R* spectrum with those reported by Shultz & Wade (2017) (for the 2015 period) and Martins et al. (2010) (for the period 2007–2009) suggests that HD 000108 might be moving towards a high-emission state, since it is much stronger than in both observations.

Finally, HD 058343 is a runaway Be star (Hoogerwerf, de Bruijne & de Zeeuw 2001; Tetzlaff, Neuhäuser & Hohle 2011) for which the SIMBAD data base provides a spectral classification of B2 Vne, although in the literature we can find spectral types that vary between

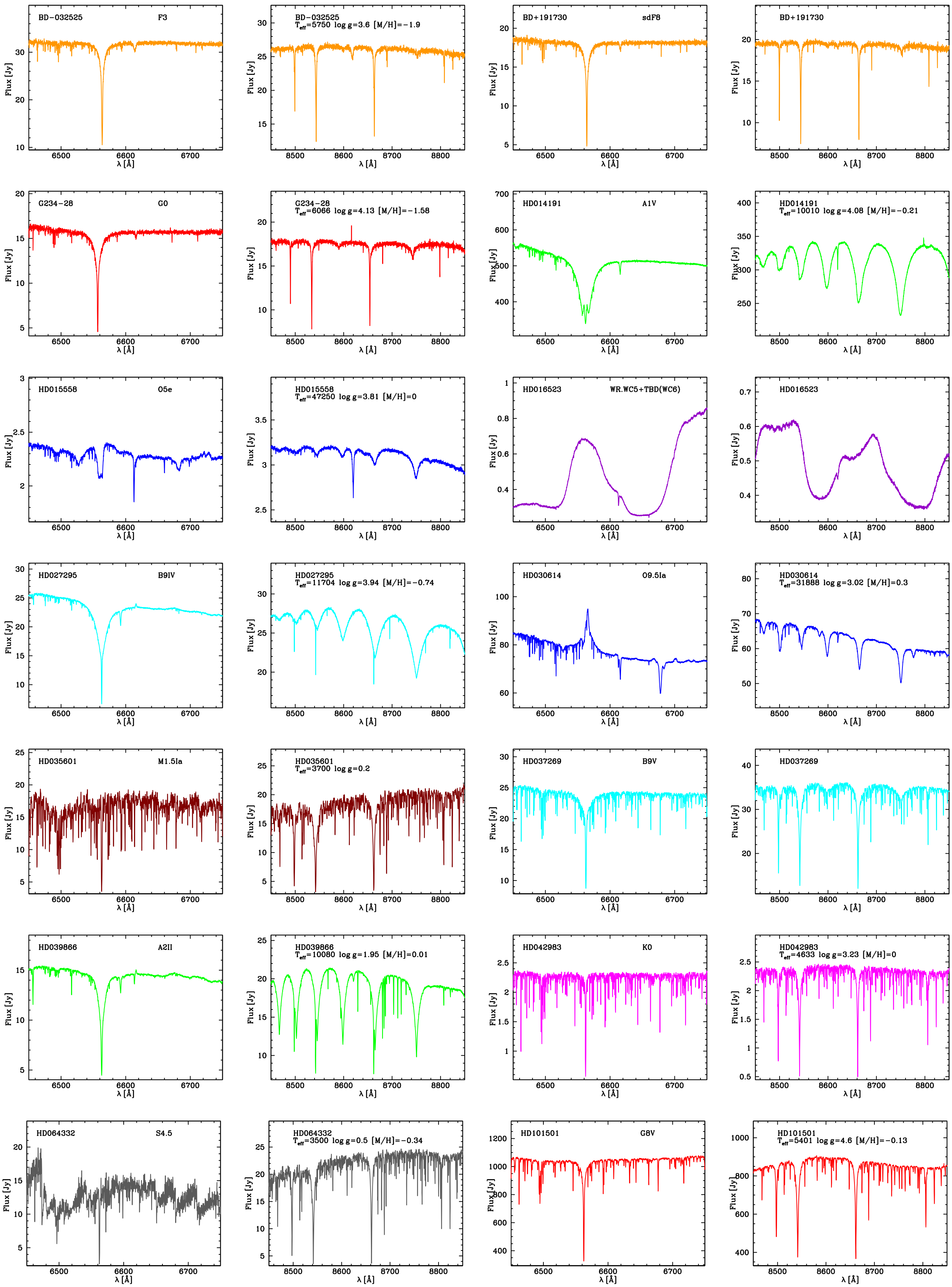

Figure 10. Extract from the MEGASTAR first-release atlas. Each row shows the HR-*R* (left) and HR-*I* (right) spectra for two observed stars. Thus, columns 1 and 3 are HR-*R* spectra while columns 2 and 4 contains HR-*I* spectra. Columns 1 and 2, or columns 3 and 4, refer to the same observation. The colour indicates the published spectral type of the star: purple, WR; blue, O; cyan, B; green, A; orange, F; red, G; magenta, K; maroon, M; and grey, S. The complete atlas is presented in Appendix A, available online only.

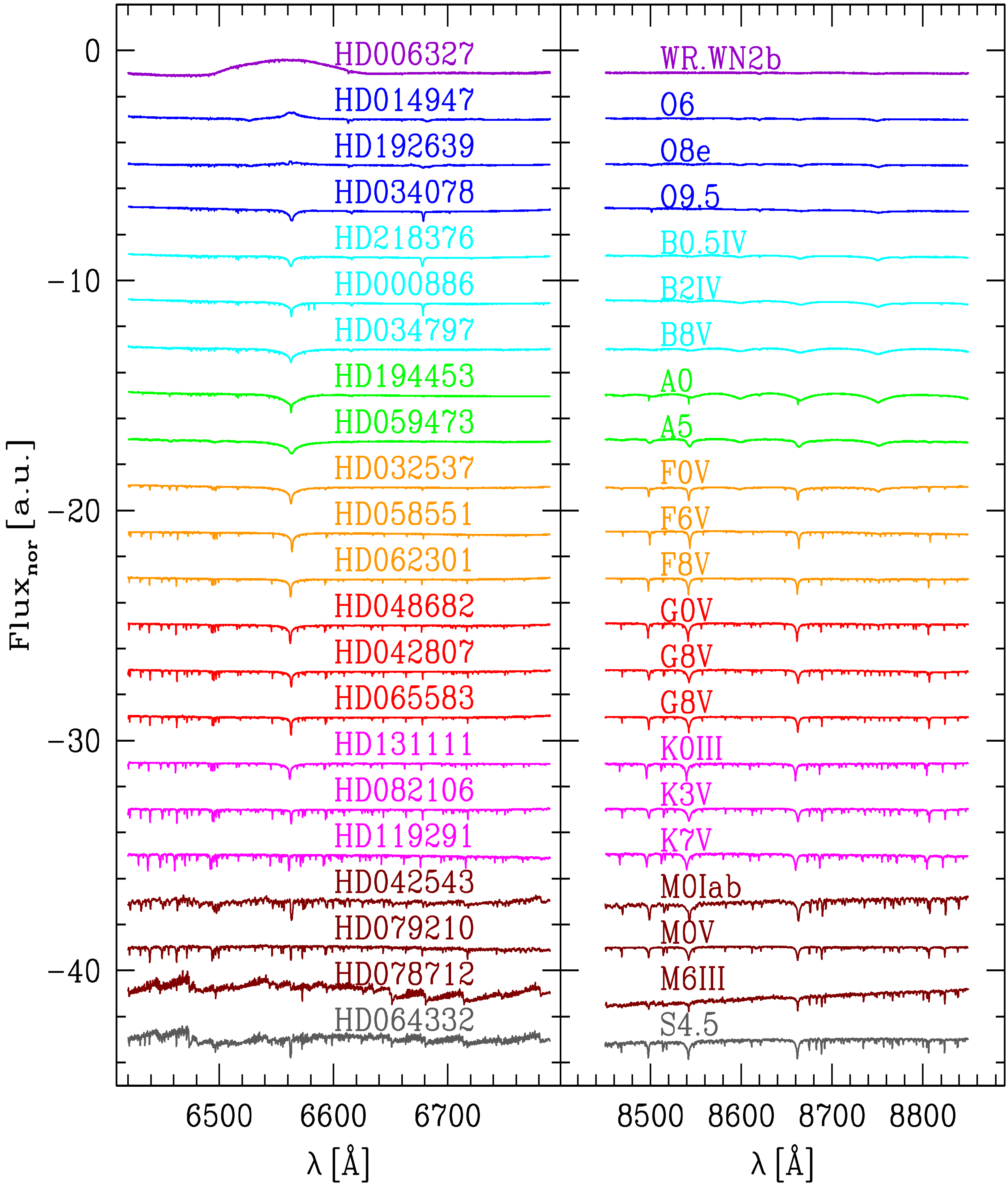

Figure 11. Sequence of some spectra from stars of the first release with different spectral types. The left-hand panels show the HR-*R* set-up spectra while the right-hand ones display the corresponding HR-*I* set-up spectra. Each spectrum has the name of the star in the left-hand panel, while the corresponding spectral type is labelled in the right-hand one.

B2 and B4 (e.g. Indo–US library, Silaj et al. 2010; Ahmed & Sigut 2017; Cochetti et al. 2020). Stellar parameters and H α line profile variability has been investigated by Arcos et al. (2018) and Ahmed & Sigut (2017) within the BeSOS and MiMeS surveys, respectively. Our spectrum clearly shows strong emission in the H α line profile. We highlight that all Paschen lines appear in emission with absorption wings.

These examples show the variety of line profiles that can be found in the spectra of massive hot stars. They are strongly affected by different factors that play an important role in their evolutionary

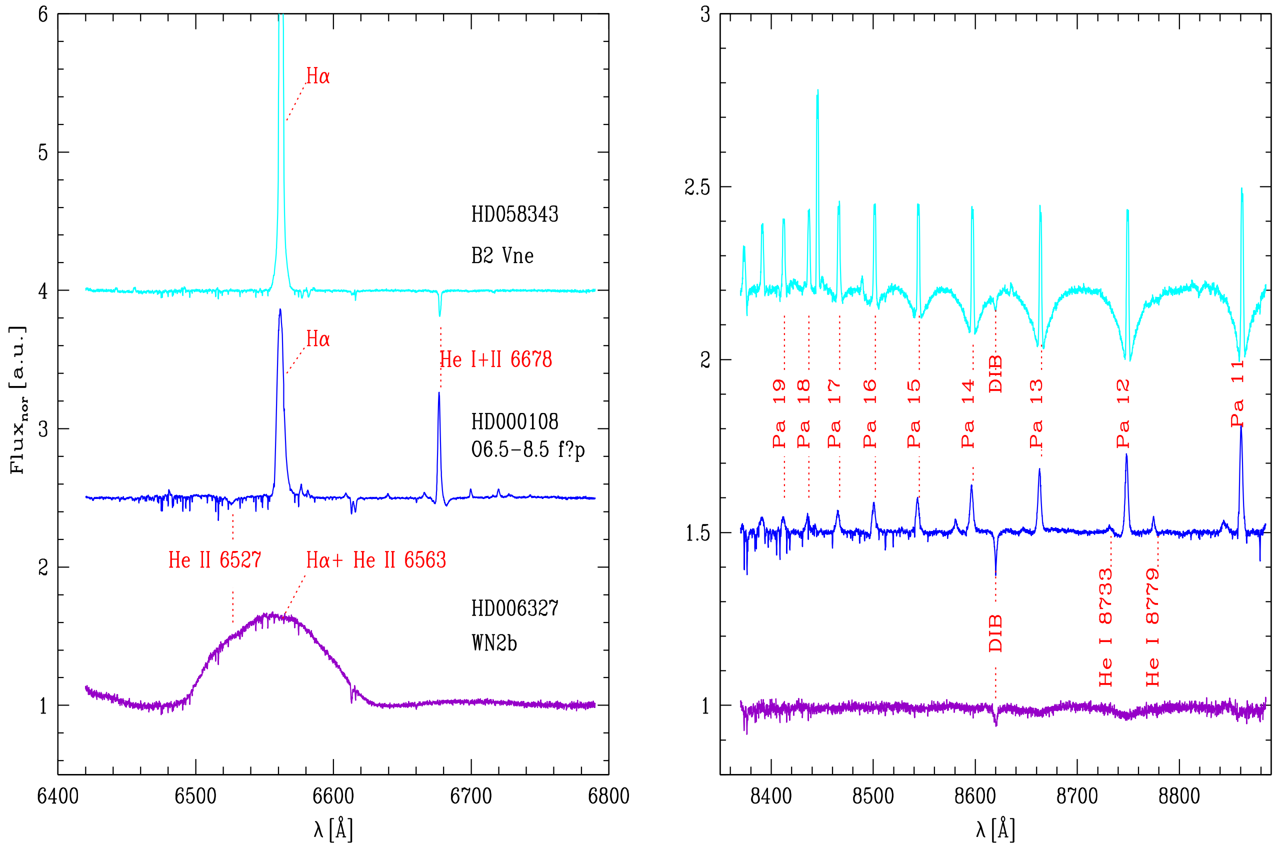

Figure 12. Normalized spectra of three hot stars of this first release: HD 058343 (cyan), HD 000108 (blue), and HD 006327 (purple) in the two spectral configurations: HR-*R* (left) and HR-*I* (right). The star names and spectral types are indicated in black while the main hydrogen and helium lines are shown with the identification labelled in red.

behaviour, such as rotation, binarity, magnetic fields, or strong stellar winds (Langer 2012). Therefore, the inclusion of high-quality OB star spectra in the MEGASTAR data base, which will increase in future releases, can help to study their physics, providing empirical data to constrain the complex theoretical evolutionary models of young stellar populations.

6.3 Additional data: *Gaia* DR2

As complementary information to the first release, in Appendix C we include *Gaia* DR2 measurements for 388 stars of the MEGASTAR library and additional useful information. In Table 4 the columns headers of Appendix C are described. The *Gaia* DR2 data included were retrieved using the PYTHON interface for querying the VizieR web service provided by ASTROQUERY,[5] and an affiliated package of ASTROPY.[6] The table incorporates the default columns that are pre-selected when accessing the catalogue I/345/gaia2 (Gaia Collaboration et al. 2018). For completeness, the table includes, when available, the *Hipparcos* (Høg et al. 2000) and *Tycho* (van Leeuwen 2007) identifications, as well as the specific designation when the objects are recognized as known variable stars in the SIMBAD data base.

[5]https://astroquery.readthedocs.io/en/latest/vizier/vizier.html
[6]http://www.astropy.org, (Astropy Collaboration et al. 2018).

7 SUMMARY

In this paper we present the first release (1.0) of the MEGARA-GTC stellar spectral (MEGASTAR) library composed of 838 spectra from 414 different stars of a wide range of spectral types and hence physical parameters.

All the spectra are given reduced and calibrated with MEGARA DRP, which has been proved to be robust and reliable. The data have passed through all standard reduction steps: bias subtraction, fibre tracing and extraction, flat-field and wavelength calibration, instrument response correction, and flux calibration (Jy). The spectra were all taken as *filler*-type GTC open-time observations and were observed under different seeing conditions. Nevertheless, as we extracted 37 spaxels around the star's centroid position, most of the flux is guaranteed for seeing better than 2.5 arcsec. The spectra were extracted in the same wavelength intervals: 6420–6790 Å in HR-*R* and 8370–8885 Å in HR-*I*.

We have compiled an atlas with all 838 spectra (Appendix A), the main characteristics of the stars in the release sample (Appendix B), and the *Gaia* DR2 data for 388 stars, from the 414 observed, shared with our release 1.0 sample (Appendix C). We have described in this work the atlas and table contents but the three appendices will be published online only.

We have developed a data base that has allowed us to handle the complete stellar library (2988 stars), to select and update the stars to be observed in the different semesters, and to generate complex files

Table 4. Column description of the Appendix C file, available online only. Includes data from *Gaia* DR2 for 388 stars of the MEGASTAR library.

Column	Description
Name	Star name (∗)
RA	Right ascension (2000.0) hh:mm:ss.s (∗)
Dec.	Declination (2000.0) dd:dd:ss.s (∗)
Sp. type	Spectral type (∗)
RV_VALUE	Radial velocity (km s^{-1}) (∗) (n)
U	Johnson–Cousins *U* magnitude (∗) (n)
B	Johnson–Cousins *B* magnitude (∗) (n)
V	Johnson–Cousins *V* magnitude (∗) (n)
R	Johnson–Cousins *R* magnitude (∗) (n)
I	Johnson–Cousins *I* magnitude (∗) (n)
J	Johnson–Cousins *J* magnitude (∗) (n)
H	Johnson–Cousins *H* magnitude (∗) (n)
K	Johnson–Cousins *K* magnitude (∗) (n)
Other name	Alternative name of the star (n)
T_{eff}	Effective temperature from the literature (K) (n)
log *g*	Surface gravity (log) from the literature (n)
[Fe/H]	Iron abundance (log) from the literature (n)
Reference	Original catalogue from which it was inherited (n)
Other comments	Comments relating to the star (n)
MAIN_ID	Default name in the SIMBAD data base
id_variable	ID if the star is identified as a known variable (n)
id_hipparcos	Star name in the *Hipparcos* catalogue (n)
id_tycho	Star name in the *Tycho* catalogue (n)
id_gaiadr2	Star name in the *Gaia* DR2 catalogue
RA_ICRS	Barycentric right ascension (ICRS) at Ep = 2015.5 (°)
e_RA_ICRS	Standard error of right ascension (mas)
DE_ICRS	Barycentric declination (ICRS) at Ep = 2015.5 (°)
e_DE_ICRS	Standard error of declination (mas)
Source	Unique source identifier (unique within a particular data release)
Plx	Absolute stellar parallax (mas) (n)
e_Plx	Standard error of parallax (mas) (n)
pmRA	Proper motion in RA direction (mas yr^{-1}) (n)
e_pmRA	Standard error of proper motion in RA (mas yr^{-1}) (n)
pmDE	Proper motion in Dec. direction (mas yr^{-1}) (n)
e_pmDE	Standard error of proper motion in Dec. (mas yr^{-1}) (n)
Dup	[0/1] Source with duplicate sources
FG	*G*-band mean flux (e- s^{-1})
e_FG	Error on *G*-band mean flux (e- s^{-1})
Gmag	*G*-band mean magnitude (Vega)
e_Gmag	Standard error of *G*-band mean magnitude (Vega)
FBP	Mean flux in the integrated BP band (e- s^{-1}) (n)
e_FBP	Error on the integrated BP mean flux (e- s^{-1}) (n)
BPmag	Integrated BP mean magnitude (Vega) (n)
e_BPmag	Standard error of BP mean magnitude (Vega) (n)
FRP	Mean flux in the integrated RP band (e- s^{-1}) (n)
e_FRP	Error on the integrated RP mean flux (e- s^{-1}) (n)
RPmag	Integrated RP mean magnitude (Vega) (n)
e_RPmag	Standard error of RP mean magnitude (Vega)(n)
BP-RP	BP − RP colour
RV	Spectroscopic radial velocity in the solar barycentric reference frame (km s^{-1}) (n)
e_RV	Radial velocity error (km s^{-1})
Teff_2	Stellar effective temperature from A–P (K)
AG	Estimate of extinction in the *G* band from (n)
E(BP-RP)	Estimate of reddening from A–P (n)
Rad	Estimate of radius from A-FLAME (solRad) (n)
Lum	Estimate of luminosity from A-FLAME (solLum) (n)

Notes. (∗) Source: SIMBAD.
(n) indicates a possible blank or null column.
A–P: APSIS–PRIAM.
A-FLAME: APSIS–FLAME.

for the GTC Phase 2 tool to prepare the selected observations while guaranteeing a large enough number of stars ready to be observed any night due to the nature of the *filler*-type program.

All the 838 reduced and calibrated spectra of this release, MEGASTAR 1.0, will be immediately public after the acceptance of this article and available to the whole scientific community. To facilitate the use of the released data, we have developed a web page with a web-based tool and a graphic interface to access and visualize the spectra (https://www.fractal-es.com/megaragtc-stellarlibrary). The users can access the data of 2988 stars in the MEGASTAR catalogue, retrieve or visualize the individual spectra obtained in both spectral configurations, HR-*R* and HR-*I*, and download the complete release.

We are confident that the 838 spectra of this MEGASTAR 1.0 release will be a precious tool to generate composed populations for the interpretation of MEGARA data, but also that they will be an attractive resource for stellar astronomers interested in the study of the individual stars at this high resolution and wavelength intervals, specifically the HR-*I* range with very few available data.

ACKNOWLEDGEMENTS

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We are very grateful to the reviewer as her/his comments and suggestions improved the manuscript.

DATA AVAILABILITY

The fully reduced and calibrated spectra of MEGASTAR first release are available at https://www.fractal-es.com/megaragtc-stellarlibrary. The access username is *public* and the password is *Q50ybAZm*.

The supplementary material described as Appendices A, B, and C is available online only. A summary of their content follows.

Appendix A is an atlas of the 838 spectra of the 414 stars of this data release, i.e. the plots of all the spectra are shown. The information in the appendix is described by a table to find the page where the spectra for each star are located. This table is in the main manuscript as Table 5. The atlas is available as a PDF format file.

Appendix B is a table with the information associated with this data release. The columns description is given in Table 3 of the

Table 5. Summary of the stars of the MEGASTAR first release whose spectra are shown in Appendix A, available online only. The first column is the page number of Appendix A where the spectra can be found. The stars are listed in the same order that they are displayed in each page of this atlas.

Page	Stars						
A3	BD−032525	BD−122669	BD+083095	BD+092190	BD+130013	BD+191730	BD+195116B
	BD+203603	BD+241676	BD+262606	BD+351484	BD+381670	BD+511696	BD+541399
A4	BD+800245	G171−010	G197−45	G202−65	G234−28	HD 000108	HD 000358
	HD 000560	HD 000886	HD 003360	HD 003369	HD 003628	HD 003644	HD 004004
A5	HD 004539	HD 006327	HD 006815	HD 007374	HD 009974	HD 009996	HD 013267
	HD 013268	HD 014191	HD 014633	HD 014947	HD 015318	HD 015558	HD 015570
A6	HD 015629	HD 016429	HD 016523	HD 016523	HD 016581	HD 017081	HD 017145
	HD 017506	HD 017638	HD 017638	HD 018144	HD 018296	HD 018409	HD 019308
A7	HD 020084	HD 020512	HD 021742	HD 022484	HD 023862	HD 024341	HD 024451
	HD 024534	HD 024912	HD 025173	HD 025825	HD 026756	HD 027126	HD 027282
A8	HD 027295	HD 027371	HD 027524	HD 027685	HD 028005	HD 029645	HD 030614
	HD 030649	HD 030676	HD 031219	HD 031293	HD 031374	HD 031996	HD 032537
A9	HD 033632	HD 033904	HD 034078	HD 034255	HD 034797	HD 034816	HD 035468
	HD 035497	HD 035601	HD 035961	HD 036066	HD 036130	HD 036165	HD 036395
A10	HD 036512	HD 036960	HD 037202	HD 037269	HD 037272	HD 037394	HD 037526
	HD 037742	HD 037958	HD 038230	HD 038529	HD 038650	HD 038856	HD 038899
A11	HD 039587	HD 039773	HD 039801	HD 039866	HD 040801	HD 040964	HD 041117
	HD 041330	HD 041357	HD 041501	HD 041692	HD 041808	HD 042035	HD 042250
A12	HD 042353	HD 042543	HD 042597	HD 042807	HD 042983	HD 043042	HD 043153
	HD 043264	HD 043285	HD 043286	HD 043526	HD 044109	HD 044274	HD 044537
A13	HD 044614	HD 045321	HD 045391	HD 045410	HD 045829	HD 045910	HD 046223
	HD 046317	HD 046380	HD 046480	HD 046588	HD 046703	HD 047127	HD 047309
A14	HD 047839	HD 048279	HD 048682	HD 049330	HD 049409	HD 049732	HD 050522
	HD 050696	HD 051219	HD 051309	HD 051530	HD 052711	HD 053929	HD 054371
A15	HD 054717	HD 055280	HD 055575	HD 055606	HD 056925	HD 056925	HD 058343
	HD 058551	HD 058946	HD 059473	HD 060179	HD 060501	HD 061606	HD 062301
A16	HD 062613	HD 063302	HD 063778	HD 064090	HD 064332	HD 064412	HD 064606
	HD 065123	HD 065583	HD 066573	HD 067767	HD 068017	HD 068638	HD 069897
A17	HD 069897	HD 070298	HD 071148	HD 071310	HD 071881	HD 072184	HD 072905
	HD 072946	HD 072968	HD 073344	HD 073668	HD 074000	HD 074156	HD 074280
A18	HD 074377	HD 075302	HD 075318	HD 075333	HD 075732	HD 075782	HD 076813
	HD 076943	HD 078175	HD 078209	HD 078249	HD 078362	HD 078418	HD 078712
A19	HD 079028	HD 079210	HD 079452	HD 079765	HD 080081	HD 080218	HD 080536
	HD 082106	HD 083425	HD 084737	HD 086133	HD 086560	HD 086728	HD 086986
A20	HD 088446	HD 088609	HD 088725	HD 088737	HD 089010	HD 089125	HD 089269
	HD 089307	HD 089744	HD 089995	HD 090537	HD 090839	HD 094028	HD 094835
A21	HD 095128	HD 095241	HD 096094	HD 096436	HD 097560	HD 097855	HD 097916
	HD 099028	HD 099747	HD 100030	HD 100446	HD 100563	HD 100696	HD 101107
A22	HD 101177	HD 101177B	HD 101227	HD 101501	HD 101606	HD 101690	HD 102870
	HD 104556	HD 104979	HD 104985	HD 105087	HD 106038	HD 106156	HD 107213
A23	HD 107328	HD 107582	HD 108177	HD 109358	HD 109995	HD 110897	HD 112735
	HD 113002	HD 114606	HD 114710	HD 114762	HD 115136	HD 115383	HD 116316
A24	HD 117176	HD 117243	HD 118244	HD 119291	HD 120136	HD 123299	HD 124570
	HD 125560	HD 126271	HD 126511	HD 126512	HD 126660	HD 128167	HD 128987
A25	HD 129174	HD 129336	HD 131111	HD 131156	HD 131156B	HD 131507	HD 132756
	HD 134083	HD 134113	HD 135101	HD 137391	HD 138573	HD 138749	HD 138764
A26	HD 139457	HD 141004	HD 141272	HD 142091	HD 142860	HD 142926	HD 143807
	HD 144206	HD 144284	HD 145148	HD 145389	HD 147394	HD 147677	HD 148816
A27	HD 149121	HD 149161	HD 155358	HD 155763	HD 160762	HD 164353	HD 165029
	HD 165358	HD 165670	HD 166046	HD 169822	HD 173524	HD 174912	HD 175535
A28	HD 176437	HD 180554	HD 183144	HD 185936	HD 187123	HD 187879	HD 188001
	HD 188209	HD 189087	HD 190229	HD 190603	HD 192639	HD 192907	HD 193432
A29	HD 193793	HD 194453	HD 195198	HD 195592	HD 196426	HD 196610	HD 198183
	HD 198478	HD 199478	HD 199579	HD 200580	HD 206165	HD 206374	HD 208501
A30	HD 209459	HD 209975	HD 210809	HD 211472	HD 212076	HD 212442	HD 212454
	HD 212593	HD 213420	HD 214080	HD 214167	HD 214168	HD 214680	HD 215512
A31	HD 215704	HD 216831	HD 216916	HD 217086	HD 217833	HD 217891	HD 218045
	HD 218059	HD 218376	HD 220182	HD 220787	HD 220825	HD 220933	HD 221585
A32	HD 221830	HD 224544	HD 224559	HD 224801	HD 224926	HD 224926	HD 225160
	HD 233345	HD 233511	HD 237846	HD 241253	LHS10	Ross−889	

main manuscript. This appendix is provided in ASCII and MSEXCEL formats.

Appendix C is a table with the available information in *Gaia* DR2 for the 388 stars it has in common with the MEGASTAR library. The column description is given as Table 4 in the main manuscript. This appendix is provided in ASCII and MSEXCEL formats.

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SUPPORTING INFORMATION

Supplementary data are available at *MNRAS* online.

Table S1. Summary of the stars of the MEGASTAR first release whose spectra are shown in this appendix.
Figure S1. Stellar spectra ordered by name, given in each plot, for this release I catalogue.

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